Towards a New Understanding of the Formation of Aspherical Planetary Nebulae from AGB stars: The Impact of HST

Raghvendra Sahai
Jet Propulsion Laboratory, MS 183-900, California Institute of Technology, Pasadena, CA 91109

Following the succesful installation of the Wide Field Planetary Camera 2 (WFPC2) aboard the Hubble Space Telescope (HST) in Dec 1993, a substantial and growing number of young planetary and proto-planetary nebulae have recently been imaged at optical wavelengths with unprecedented high angular resolution and dynamic range. These studies, undertaken through the Guaranteed Time Observations (GTO) and Guest Observer (GO) programs, include program focussed on specific objects, as well as survey programs through the SNAPshot observing mode of HST.

These data in general, and in particular, results from an HST WFPC2 H-alpha SNAPshot imaging survey of young planetary nebulae (PNe) by Sahai and Trauger (1998) show that young PNe have highly aspherical morphology. The WFPC2 images of these young PNe, selected only on the basis of theirlow excitation characteristics, are characterised by multipolar bubbles distributed roughly point-symmetrically around the central star. In some objects, bipolar ansae or collimated radial structures are seen, indicating the presence of jets, whereas in others bright structures near the minor axes indicate the presence of disks or torii. Detailed imaging of bipolar PPNe such as CRL2688, as well as archival data from a SNAPshot survey of PPNe, show that the development of complex asymmetries during the PPNe phase. The complexity, organization and symmetry of the these structures is forcing a shift in the current paradigm that a pre-existing equatorial density enhancement in the dense wind of the AGB progenitor is the primary agent for producing asymmetric planetary nebulae.

In this paper, we critically review the HST data, and show that it supports a model for PN formation in which the primary agent for shaping PNe are high-speed collimated outflows or jets which operate during the late AGB and/or early post-AGB evolutionary phase. These outflows carve out a complex imprint within an intrinsically spherical AGB circumstellar envelope (CSE). Subsequent expansion of a hot, tenuous stellar wind from the post-AGB star inside the imprinted AGB CSE then produces the observed PN, whose shape and structure depend in detail on how the characteristics of the jets change with time.